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XII.

BRIEF CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF HARVARD COLLEGE,

UNDER THE DIRECTION OF

JOHN TROWBRIDGE, ASSISTANT-PROFESSOR OF PHYSICS.

No. II. — ON A NEW INDUCTION COIL.

Read, April 13, 1875.

In the best constructed induction coils of the present day, the electro-magnet is prolonged beyond the induction coil; so that the latter occupies the middle of the electro-magnetic core, where the inductive effect is the greatest. The core of the electro-magnet consists of a bundle of iron wires, which, by their want of continuity of mass, break up the currents of induction which form in the mass of a large solid core, and prevent the sudden breaking of the electro-magnetic circuit, which is so desirable, in order to produce great effects of tension.

The preceding experiments, made with armatures to electro-magnets, which I suggested to Mr. Lefavour and Mr. Peirce, led me to think that the effect of an induction coil could be increased by providing its core with an armature. I first experimented with a horseshoe-shaped solid core, 2.5 cm. in diameter; the limbs of which were 12 cm. long, and the distance between the limbs was also 12 cm. On one of the limbs was slipped a coil of thick copper wire, of .07 of an ohm resistance. The induction coil, which was of copper wire, one ohm in resistance, was distributed uniformly over the primary coil. The induction coil was connected with a Thomson's reflecting galvanometer. The following table shows the results which were obtained when the circuit was broken in the primary coil. The deflections at making the circuit are not given, since they were equal to those produced by breaking the circuit; and the study of the induction currents produced by breaking are the most important for our present purpose. The induction currents were first obtained without the use of an armature upon the two limbs of the electro-magnet, and then with the armature in position.

TABLE I.

Deflection without Armature.	Deflection with Armature.
60	130
61	130
60	129
62	130
60	135

This table shows that the strength of the induced currents was increased one hundred per cent by the application of the armature. In the above experiments the armature rested upon the limbs of the electro-magnet directly at the poles of the electro-magnet; and the ends of the limbs of the horseshoe-shaped core were filed plane, so that the armature rested completely upon them. The armature should have a length equal to the distance between the poles of the electro-magnet.

The above experiments were then repeated with cores made of small iron wire, tied in bundles, which were horseshoe in form, in order to determine whether a core of this nature differed from a solid one. The preceding results were sustained. Some difficulty was met in filing the ends of the bundle of iron wires, so that the armature should rest completely upon them, but this was a mechanical difficulty only. I next proceeded to experiment on a larger scale. The primary circuit was wound upon one limb of a horseshoe-shaped core, the limbs of which were 26 cm. long, 4 cm. in diameter, and the centres of which were 19 cm. apart. The primary coil consisted of four turns of thick copper wire, having a total resistance of .10 of an ohm. This covered one limb of the horseshoe uniformly; the other limb was not covered. The secondary coil had a resistance of 6,000 ohms, and the height of the secondary coil was equal to that of the primary. A condenser was placed in the primary circuit, which was also provided with an interrupter or break-piece. At first I endeavored to ascertain by measuring the length of the spark, produced by breaking the primary circuit, the advantage of placing an armature upon the poles of the electro-magnet. Very contradictory results were obtained; and at first sight it did not appear that any advantage resulted from the use of the armature. I next, having drawn the terminals of the secondary coil apart, so that a spark could just leap across the interval, counted the number of sparks with breaks of the primary circuit one second apart. The following table gives a series of results: —

Without the Armature.		With the Armature.	
At the end of 14 seconds,	8	At the end of 14 seconds,	12
” ” ”	5	” ” ”	10
” ” ”	6	” ” ”	9
” ” ”	4	” ” ”	10
” ” ”	8	” ” ”	13
” ” ”	9	” ” ”	13
” ” ”	7	” ” ”	9
” ” ”	7	” ” ”	5
	54		81

This method of observation, however, was far from satisfactory; the passage of the sparks was very capricious, and it often seemed as if the armature was of no advantage; although, if the trials were extended over a sufficiently large interval, a gain was shown in using the armature. I speedily resolved to make use of one of Sir William Thomson's new quadrant electrometers, and to measure the difference of potential of the terminals of the secondary coil directly. The coils were arranged as previously, and by means of a peculiarly constructed key the electrometer terminals were connected with those of the secondary coil. A small grove cell of the Elliott pattern was used. This cell, however, was very much weakened by a shunt. The following tables show the results which were obtained; the deflections are expressed in the divisions of the electrometer scale.

WITHOUT THE ARMATURE.

Deflections produced by making the Primary Circuit.	Deflections produced by breaking the Primary Circuit.
30	35
27	33
31	34
23	30
Mean, 27	Mean, 33

WITH THE ARMATURE.

Deflections produced by making the Primary Circuit.	Deflections produced by breaking the Primary Circuit.
75	83
70	77
74	83
75	83
Mean, 73	Mean, 81

It will be seen by the above tables that the difference of potential is more than doubled by the application of the armature. These experiments were conducted with solid cores, on account of the difficulty, with the means at my immediate command, of making the ends of bundles of iron wire sufficiently plane. Experiments were next made to determine the influence of the size of the armature. The following table shows the results: —

TABLE II.

Weight of Armature.	Deflections.
Grammes.	
480	130
300	131
240	130
100	129
150	130

The mass of the armature, therefore, appeared to make no difference. Experiments speedily showed, however, that the induced currents were affected by the amount of bearing surface of the armature and the disposition of its mass between the two poles of the electro-magnet of the horseshoe on which the primary coil was placed. There is no doubt that the core of the electro-magnet should consist of small iron wires, as in the ordinary Ruhmkorf coil. The iron core, with the armature, would then be in the form of a hollow square, one side of which is made up of a bundle of fine iron wires, and the remaining three equal sides constitute the armature. It appears from the above investigation that we can reduce the expense of the present form of induction coil, for a much less number of winding of fine wire will be needed when an armature is employed, to produce the same strength of induced currents that are produced in straight electro-magnets without armatures.